U.S. Department of Transportation
Federal Highway Administration

Federal Highway Administration
RESOURCE CENTER

April 28, 2008

Developing Strong Justifications for Design Exceptions

What We'll Talk About

- Brief overview of FHWA Design Exceptions
- Risk Management & Mitigation
- Example of Safety-Design Analysis Technique

Design Exceptions

"…designs which do not conform to the minimum criteria as set forth in the standards, policies, and standard specifications."

Basis for Design Criteria

code of federal regulations

§ 625.3 Application.

(a) *Applicable Standards.* (1) Design and construction standards for new construction, reconstruction, resurfacing (except for maintenance resurfacing), restoration, or rehabilitation of a highway on the NHS (other than a highway also on the Interstate System or other freeway) shall be those approved by the Secretary in cooperation with the State highway departments. These standards may take into account, in addition to the criteria described in § 625.2(a), the following:

(i) The constructed and natural environment of the area;

(ii) The environmental, scenic, aesthetic, historic, community, and preservation impacts of the activity; and

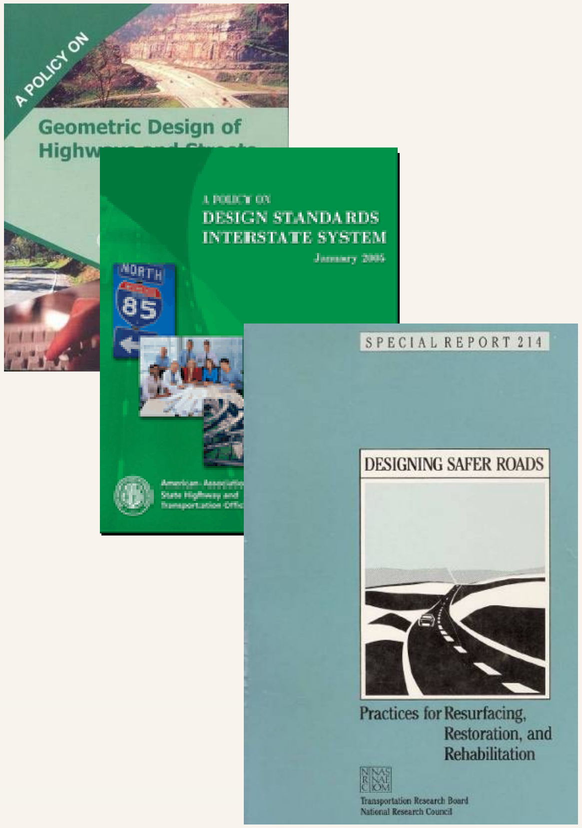
(iii) Access for other modes of transportation.

§ 625.4 Standards, policies, and standard specifications.

(a) *Roadway and appurtenances.* (1) A Policy on Geometric Design of Highways and Streets, AASHTO 2001. [See § 625.4(d)(1)]

(2) A Policy on Design Standards Interstate System, AASHTO, January 2005. [See § 625.4(d)(1)]

(3) The geometric design standards for resurfacing, restoration, and rehabilitation (RRR) projects on NHS highways other than freeways shall be the procedures and the design or design criteria established for individual projects, groups of projects, or all nonfreeway RRR projects in a State, and as approved by the FHWA. The other geometric design standards in this section do not apply to RRR projects on NHS highways other than freeways, except as adopted on an individual State basis. The RRR design standards shall reflect the consideration of the traffic, safety, economic, physical, community, and environmental needs of the projects.



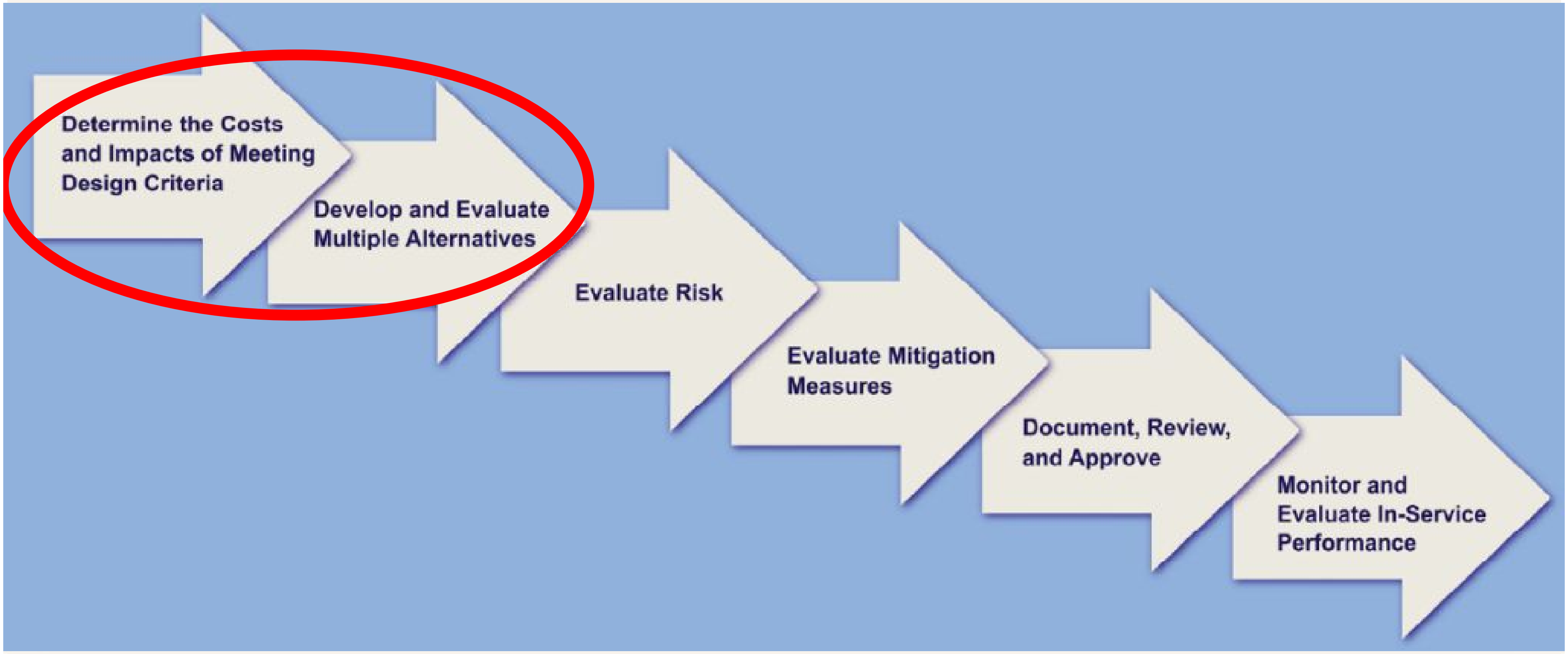
The 13 Controlling Criteria

- Design Speed
- Lane Width
- Shoulder Width
- Bridge Width
- Horizontal Alignment
- Superelevation
- Cross Slope
- Vertical Alignment
- Grade
- Stopping Sight Distance
- Vertical Clearance
- Horizontal Clearance (Lateral Offset to Obstruction)
- Structural Capacity

Common Reasons for Considering Exceptions

- Impacts to the natural environment
- Social or right-of-way impacts
- Preservation of historic or cultural resources
- Sensitivity to context or accommodating community values
- Construction or right-of-way costs

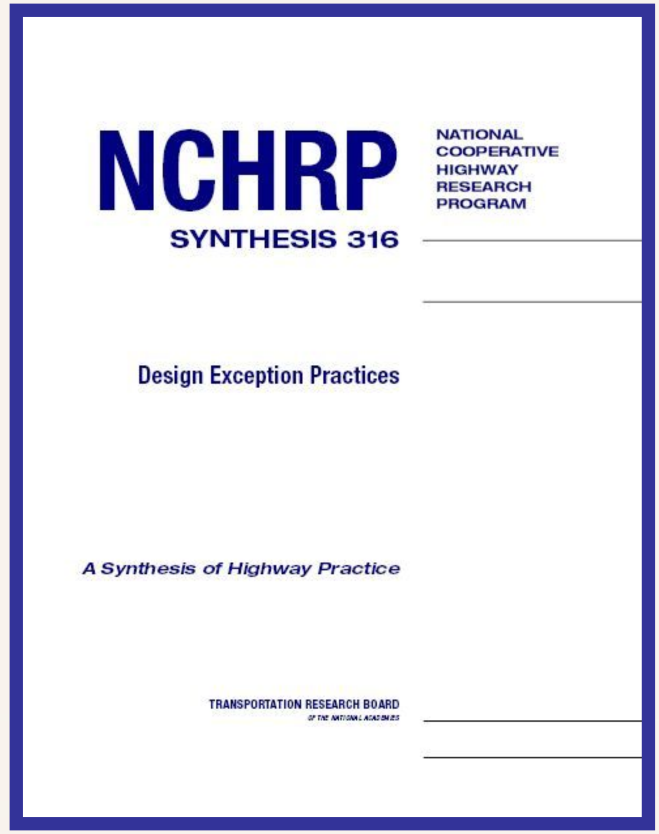
Desirable Design Exception Process



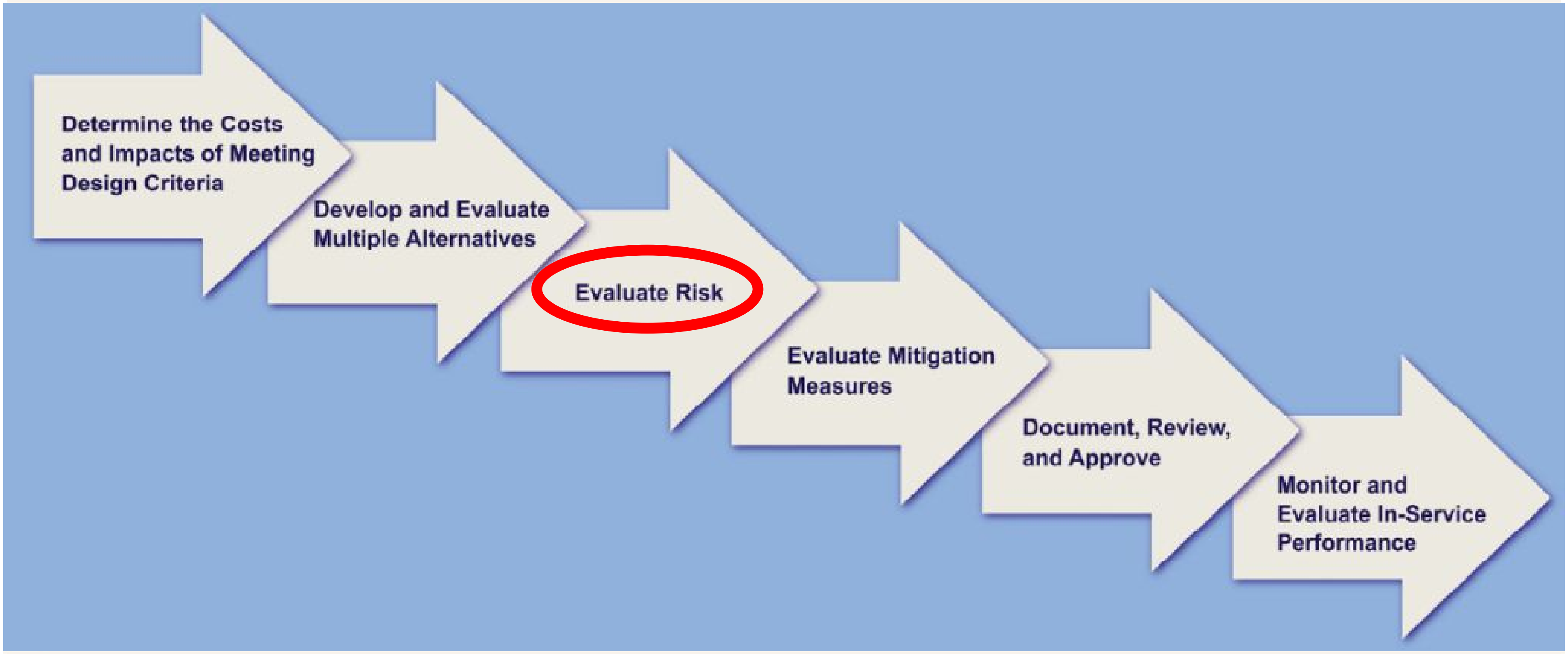
Common Types of Design Exceptions

Most Frequently Processed Elements:

1. Shoulder Width
2. Vertical Alignment
3. Lane Width
4. Horizontal Alignment
5. Stopping Sight Distance
6. Bridge Width
7. Grade
8. Horizontal Clearance (Lateral Offset)
9. Superelevation
10. Design Speed



The Key to Evaluating Design Exceptions



Evaluating Risk

- Not a new concept
- May involve different approaches and viewpoints
  - Who is "at risk" and what is the core motivation
    - Safety of Facility Users (i.e. motorists, pedestrians, etc.)?
    - Road Agency (tort liability concerns)?
- Underlying theme is ***managing*** the risk
  - Implication is that relying solely on standards does not guarantee a facility free of risk
  - Identifying/defining the risk is essential for managing the risk

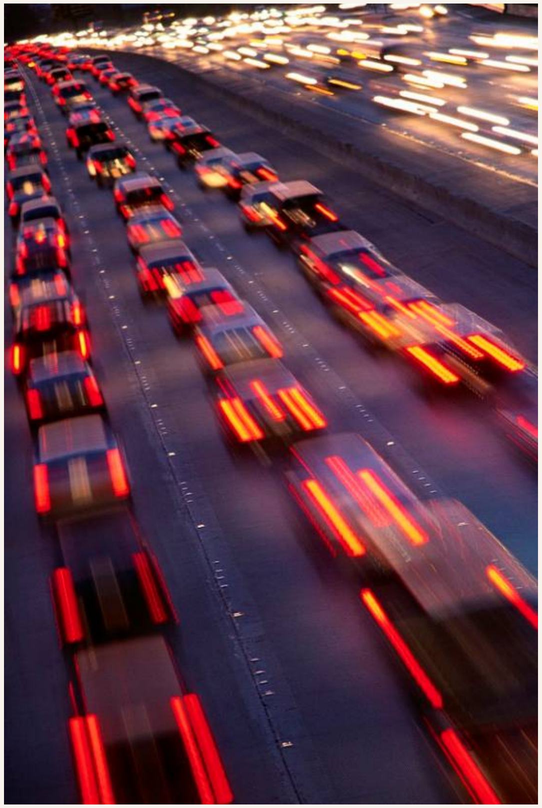
Risk Analysis for Design Exceptions

- Consideration of Safety is the central theme of accepting/approving a Design Exception

Characterize the Design Exception

What are the variables that influence Risk?

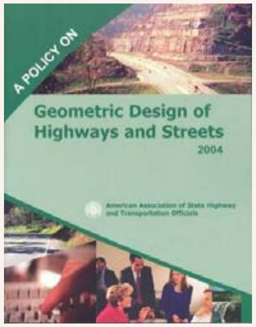
- Exposure
  - Traffic Volume
  - Location of Exception
  - Duration
- Extent
  - Degree of the exception
- Severity
  - Possible worst-case scenario outcome

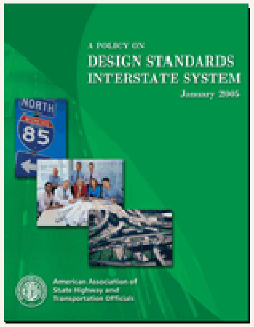


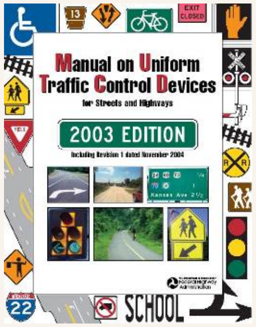
Defining Safety for Road Design

NOMINAL SAFETY

examined in reference to compliance with standards, warrants, guidelines and sanctioned design procedures

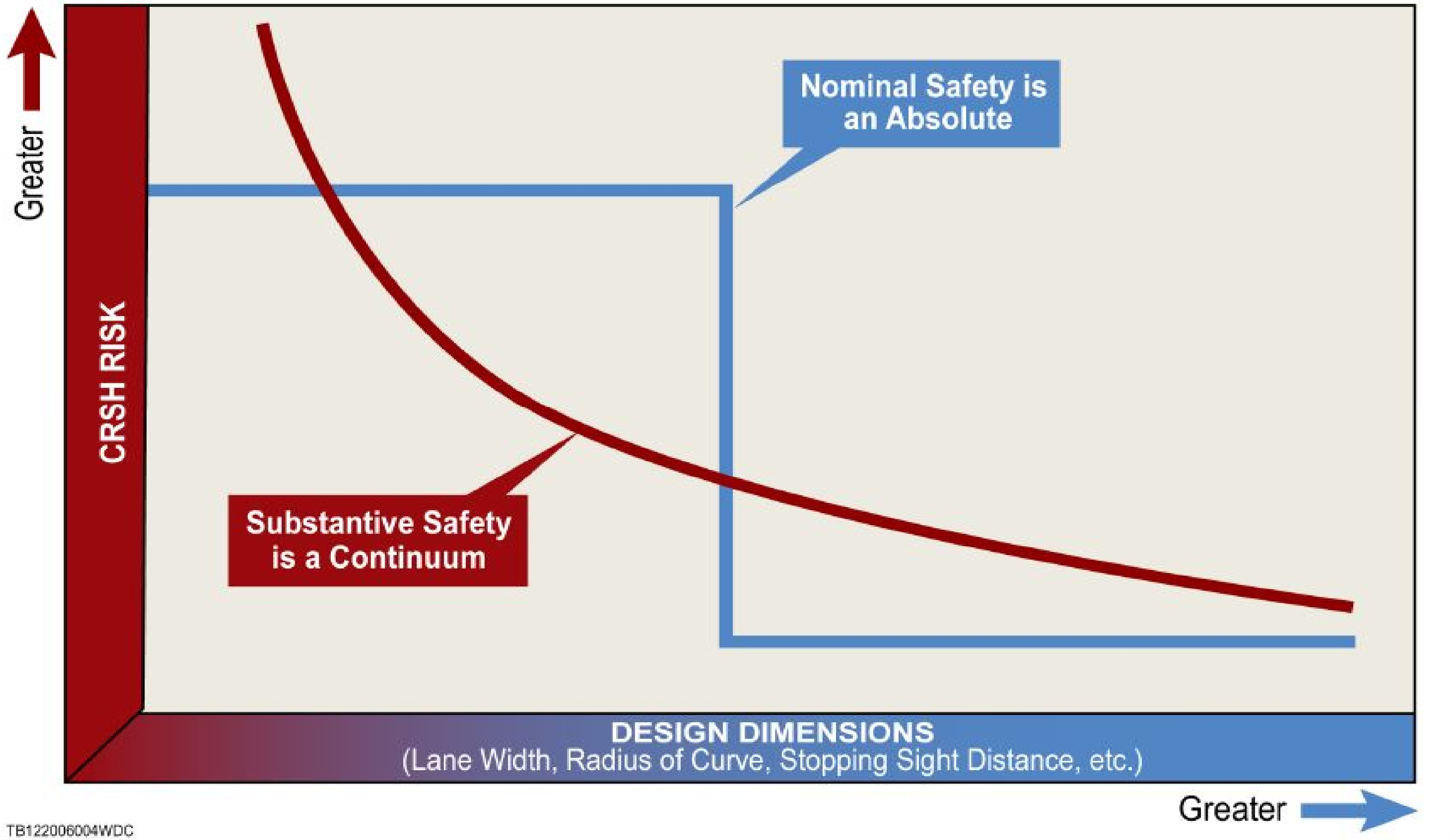






SUBSTANTIVE SAFETY

actual or expected crash frequency and severity for a highway or roadway segment or intersection


Greater
CRSH RISK
Nominal Safety is an Absolute
Substantive Safety is a Continuum
DESIGN DIMENSIONS
(Lane Width, Radius of Curve, Stopping Sight Distance, etc.)
Greater
TB122006004WDC

Qualitative Assessment: Nominal Safety

- Standard value vs. Proposed value
- Status of related design elements

US CUSTOMARY

e (%)	V_d = 15 mph R (ft)	V_d = 20 mph R (ft)	V_d = 25 mph R (ft)	V_d = 30 mph R (ft)	V_d = 35 mph R (ft)	V_d = 40 mph R (ft)	V_d = 45 mph R (ft)	V_d = 50 mph R (ft)	V_d = 55 mph R (ft)	V_d = 60 mph R (ft)	V_d = 65 mph R (ft)	V_d = 70 mph R (ft)	V_d = 75 mph R (ft)	V_d = 80 mph R (ft)
1.5	947	1680	2420	3320	4350	5520	6830	8280	9890	11700	13100	14700	16300	18000
2.0	694	1230	1780	2440	3210	4080	5050	6130	7330	8630	9720	10900	12200	13500
2.2	625	1110	1600	2200	2900	3680	4570	5540	6630	7810	8800	9860	11000	12200
2.4	567	1010	1460	2000	2640	3350	4160	5050	6050	7130	8040	9010	10100	11200
2.6	517	916	1330	1840	2420	3080	3820	4640	5550	6550	7390	8290	9260	10300
2.8	475	841	1230	1690	2230	2840	3520	4280	5130	6050	6840	7680	8580	9650
3.0	438	777	1140	1570	2060	2630	3270	3970	4760	5620	6360	7140	7990	8900
3.2	406	720	1050	1450	1920	2450	3040	3700	4440	5250	5930	6680	7480	8330
3.4	377	670	978	1360	1790	2290	2850	3470	4160	4910	5560	6260	7020	7830
3.6	352	625	913	1270	1680	2150	2670	3250	3900	4620	5230	5900	6620	7390
3.8	329	584	856	1190	1580	2020	2510	3060	3680	4350	4940	5570	6260	6990
4.0	308	547	804	1120	1490	1900	2370	2890	3470	4110	4670	5270	5930	6630
4.2	289	514	756	1060	1400	1800	2240	2740	3290	3900	4430	5010	5630	6300
4.4	271	483	713	994	1330	1700	2120	2590	3120	3700	4210	4760	5370	6010
4.6	255	455	673	940	1260	1610	2020	2460	2970	3520	4010	4540	5120	5740
4.8	240	429	636	890	1190	1530	1920	2340	2830	3360	3830	4340	4900	5490
5.0	226	404	601	844	1130	1460	1830	2240	2700	3200	3660	4150	4690	5270
5.2	213	381	569	802	1080	1390	1740	2130	2580	3060	3500	3980	4500	5060
5.4	200	359	539	762	1030	1330	1660	2040	2460	2930	3360	3820	4320	4860
5.6	188	339	511	724	974	1270	1590	1950	2360	2810	3220	3670	4160	4680
5.8	176	319	484	689	929	1210	1520	1870	2260	2700	3090	3530	4000	4510
6.0	164	299	458	656	886	1160	1460	1790	2170	2590	2980	3400	3860	4360
6.2	152	280	433	624	846	1110	1400	1720	2090	2490	2870	3280	3730	4210
6.4	140	260	409	594	808	1060	1340	1650	2010	2400	2760	3160	3600	4070
6.6	130	242	386	564	772	1020	1290	1590	1930	2310	2670	3060	3480	3940
6.8	120	226	363	536	737	971	1230	1530	1860	2230	2570	2960	3370	3820
7.0	112	212	343	509	704	931	1190	1470	1790	2150	2490	2860	3270	3710
7.2	105	199	324	483	671	892	1140	1410	1730	2070	2410	2770	3170	3600
7.4	98	187	306	460	641	855	1100	1360	1670	2000	2330	2680	3070	3500
7.6	92	176	290	437	612	820	1050	1310	1610	1940	2250	2600	2990	3400
7.8	86	165	274	416	585	786	1010	1260	1550	1870	2180	2530	2900	3310
8.0	81	156	260	396	558	754	968	1220	1500	1810	2120	2450	2820	3220
8.2	76	147	246	377	533	722	930	1170	1440	1750	2050	2380	2750	3140
8.4	72	139	234	359	509	692	893	1130	1390	1690	1990	2320	2670	3060
8.6	68	131	221	341	486	662	856	1080	1340	1630	1930	2250	2600	2980
8.8	64	124	209	324	463	633	820	1040	1290	1570	1870	2190	2540	2910
9.0	60	116	198	307	440	604	784	992	1240	1520	1810	2130	2470	2840
9.2	56	109	186	291	418	574	748	948	1190	1460	1740	2060	2410	2770
9.4	52	102	175	274	395	545	710	903	1130	1390	1670	1990	2340	2710
9.6	48	95	163	256	370	513	671	854	1080	1320	1600	1910	2260	2640
9.8	44	87	150	238	343	477	625	798	1010	1250	1510	1820	2160	2550
10.0	36	72	126	200	292	410	540	694	877	1090	1340	1630	1970	2370

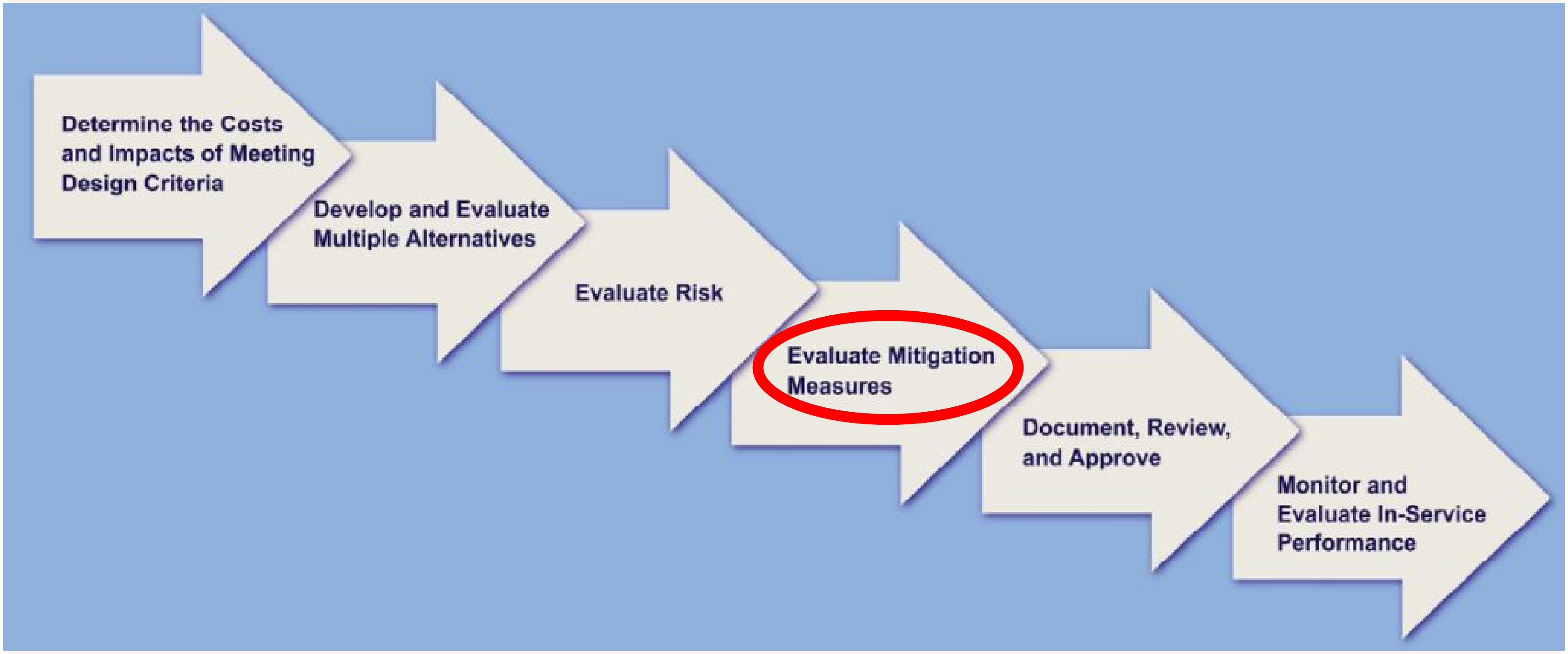
Exhibit 3-28. Minimum Radii for Design Superelevation Rates, Design Speeds, and e_{max} = 10% (Continued)

Quantitative Assessment: Substantive Safety

- Comparing crash frequencies between alternatives
- Factoring for crash types and resulting severities
- ***<u>Understanding the goal: reduce injuries & fatalities!</u>***

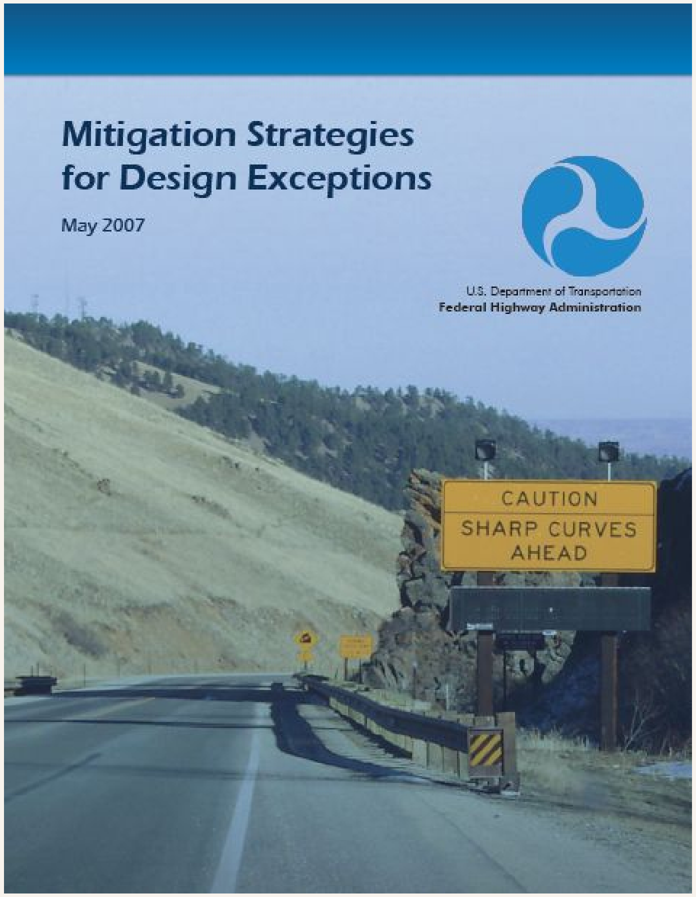
Mitigating for Design Exceptions

Mitigation is how we manage the risk!



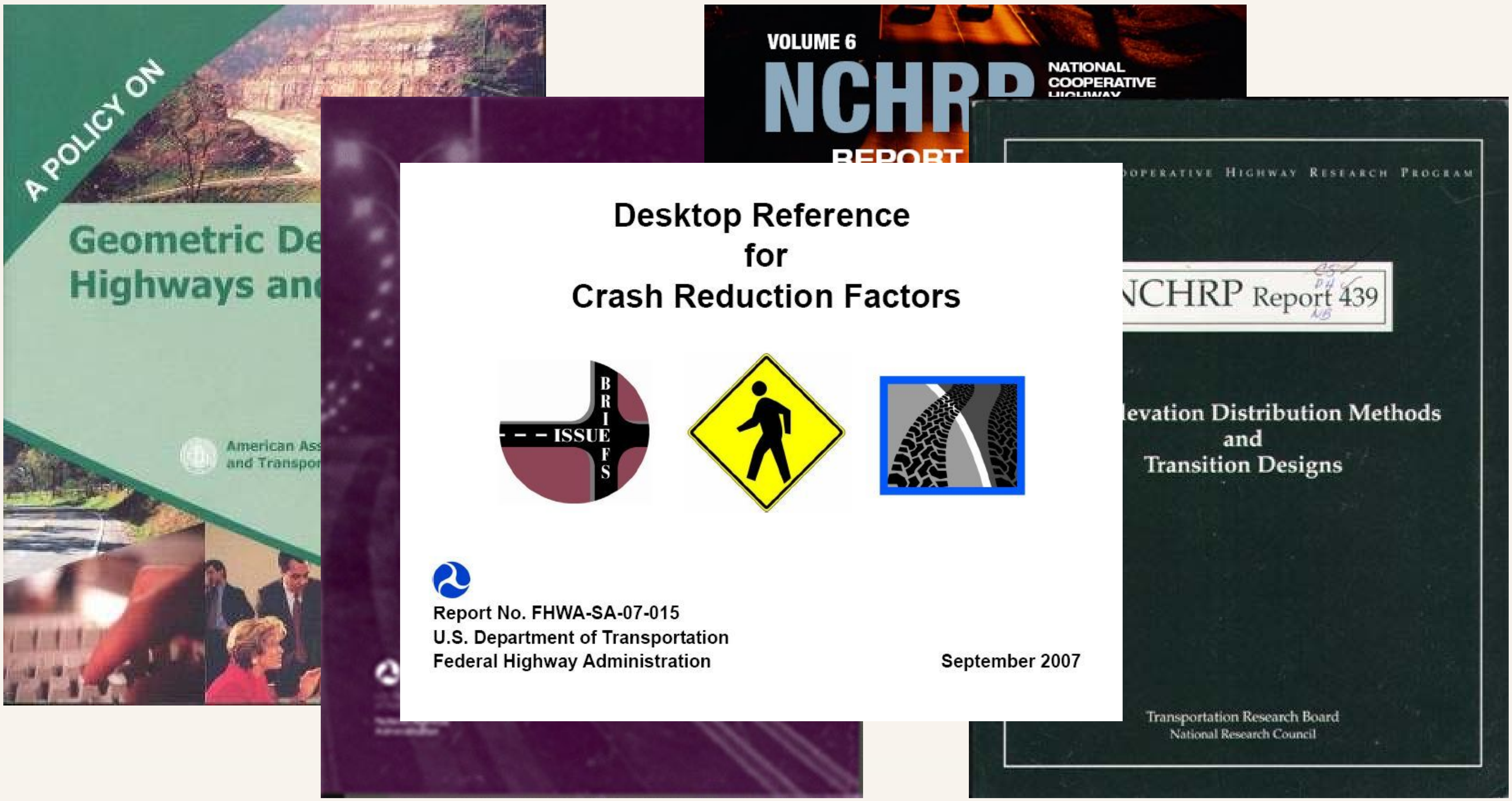
Guidance for Practitioners

"If the decision is made to go forward with a design exception, **it is especially important that measures to reduce or eliminate the potential impacts be evaluated and, where appropriate, implemented**. This guide presents and illustrates a variety of mitigation strategies, including real-world case studies from several States."



http://safety.fhwa.dot.gov/geometric/mitigationstrategies/

Sources for Mitigation Techniques & Ideas



Tools for Enhanced Analysis

- Interactive Highway Safety Design Model (IHSDM)
- www.ihsdm.org

IHSDM

"Safer Roads Through Better Design"

- Highway Safety Manual
- www.highwaysafetymanual.org

HSM

HIGHWAY SAFETY MANUAL

Allowing for the ***explicit*** consideration of safety during project development – SAFETY EFFECTS!

Example Analysis using ‘Safety Effects’ methods

An 11-mile 3R project with ADT of 13,000

Compare the safety performance differences between:

Option A: 12’ lanes with no shoulders

Option B: 11’ lanes with 1’ shoulders

$$N = [(ADT_n)(L)(365*10^{-6})(e^{-0.4865})]*AMF_{lw}*AMF_{sh}$$

$$AMF_{lw} = 1.00 \text{ @ } 12' \text{ and } 1.05 \text{ @ } 11' \text{ (base is } 12')$$

$$AMF_{sh} = 1.50 \text{ @ } 0' \text{ and } 1.40 \text{ @ } 1' \text{ (base is } 6')$$

Defining Safety Performance

Option A:

$N = [(ADT_n)(L)(365*10^{-6})(e^{-0.4865})]*AMF_{lw}*AMF_{sh}$

$N = [(13{,}000)(11)(365*10^{-6})(e^{-0.4865})]*(1.00)*(1.50)$

N = 49 crashes per year

Option B:

$N = [(ADT_n)(L)(365*10^{-6})(e^{-0.4865})]*AMF_{lw}*AMF_{sh}$

$N = [(13{,}000)(11)(365*10^{-6})(e^{-0.4865})]*(1.05)*(1.40)$

N = 48 crashes per year

Enhancing the Design

Option B would be expected to produce about an equal number of crashes annually for the project.

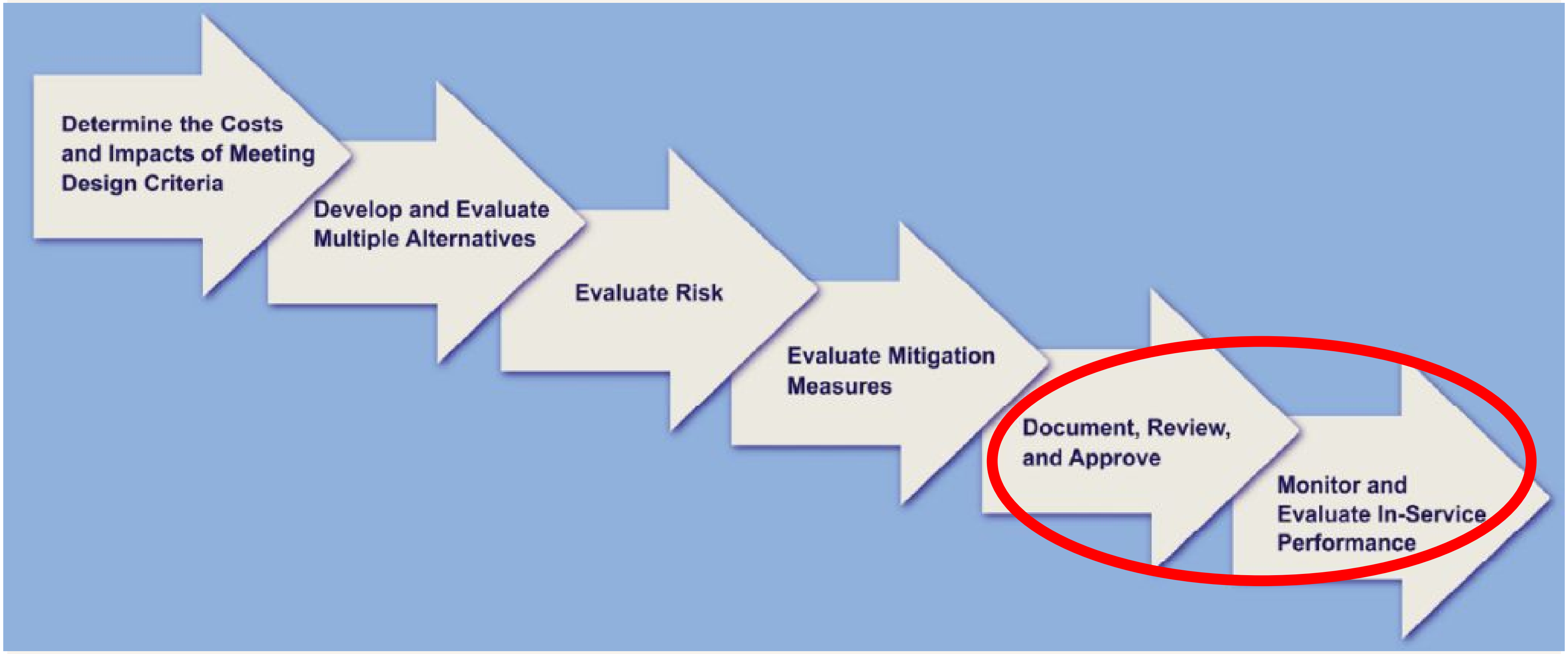
However, Option B – with a paved shoulder – can also allow for a rumble strip/stripe. Using an appropriate CRF for rumble strip/stripe on a 2-lane rural highway:

- Of 48 crashes, roughly 1/3 (16) are SVROR – correctable by shoulder rumble strips
- Apply a CRF of 13% to the 16 SVROR crashes (decrease of 2)
- Adjusted expected crashes for Option B is 46 crashes
- By analyzing the conditions and mitigating for the exception, it is possible to achieve a similar or improved safety performance!

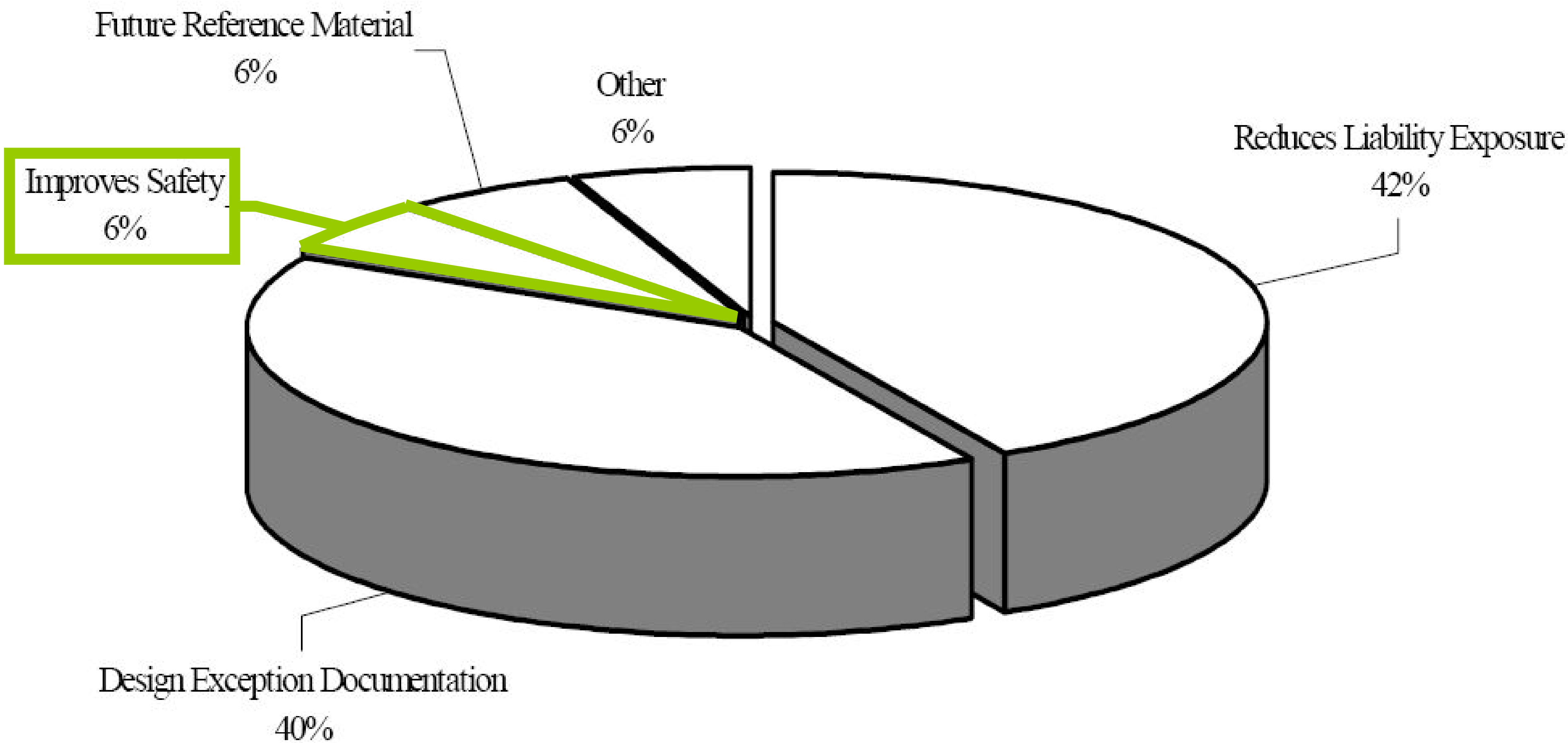

NOT
PASS

Gauging Success / Shifting the Paradigm

- In-service evaluation is the last, but equally important step
- Combining Standards-oriented <u>and</u> Performance-oriented



Benefits of Design Exceptions



Progressive State DOT Perspective

The rule of thumb for successful design exception justification is that two conditions are successfully asserted:

- No reasonable, feasible and practical solution can be devised to provide standard values for the critical design elements in question, OR
- The selection of a non-standard value or values for these elements is advantageous in some way or ways and results in an overall superior design, all things considered.
- Use of non-standard values for the elements in question will not be expected to unduly degrade or hinder the safety or operational performance of the proposed facility.

Other Thoughts on Design Exceptions

patterns & practices

proven practices for predictable results

"…sanitize unsafe exceptions by replacing them with exceptions that are ***safe by design***."

Microsoft®

Design Exceptions:
An Opportunity to Create Exceptional Designs

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